CHAPTER 2

PLANNING, LAYOUT, AND ELEMENTS OF COFFERDAMS

2-1. Areas of Consideration. For a construction cofferdam to be functional, it must provide a work area free from frequent flooding and of sufficient size to allow for necessary construction activities. These two objectives are dependent on several factors and are interrelated as described below.

a. Height of Protection. The top of the cofferdam should be established so that a dry working area can be economically maintained. To establish an economical top elevation for cofferdam and flooding frequency, stage occurrence and duration data covering the practical range of cofferdam heights must be evaluated, taking into account the required life of the cofferdam. Factors which affect the practical range of cofferdam heights include: effects on channel width to accommodate streamflow and navigation where required; increased flow velocity during high river stages and the resultant scour; effects on completed adjacent structures to which the cofferdam joins (the "tie-in"), i.e., these structures must be designed to resist pools to top of cofferdam; and practical limitations on the size of cell due to interlock stresses and sliding stability. By comparing these factors with the effects of lost time and dewatering and cleanup costs resulting from flooding, an economical top elevation of cofferdam can be established.

b. Area of Enclosure. The area enclosed by the cofferdam should be minimized for reasons of economy but should be consistent with construction requirements. The area often will be limited by the need to maintain a minimum channel width and control scour and to minimize those portions of completed structures affected by the tie-in. The minimum area provided must be sufficient to accommodate berms, access roads, an internal drainage system, and a reasonable working area. Minimum functional area requirements should be established in coordination with construction personnel.

c. Staging. When constructing a cofferdam in a river, the flow must continue to be passed and navigation maintained. Therefore, the construction must be accomplished in stages, passing the water temporarily through the completed work, and making provisions for a navigable channel. The number of stages should be limited because of the costs and time delays associated with the removal of the cells in a completed stage and the construction of the cells for the following stage. However, the number of stages must be consistent with the need to minimize streamflow velocities and their associated effects on scour, streambank erosion, upstream flooding, and navigation. When developing the layout for a multistage cofferdam, special attention should be given to maximizing the number of items common to each stage of the cofferdam. With proper planning some cells may be used for two subsequent stages. In those cells that will be common to more than one stage, the connecting tees or wyes that are to be utilized in a future stage must be located with care.

d. Hydraulic Model Studies. Hydraulic model studies are often necessary to develop the optimum cofferdam layout, particularly for a multistage cofferdam. From these studies, currents which might adversely affect navigation, the potential for scour, and various remedies can be determined.

2-2. Elements of Cofferdams.

a. Scour Protection. Flowing water can seriously damage a cofferdam cell by undermining and the subsequent loss of cell fill. Still further, scour caused by flowing water can lead to damage by increased underseepage and increased interlock stresses. The potential for this type of damage is dependent upon the velocity of the water, the eddies produced, and the erodibility of the foundation material. Damage can be prevented by protecting the foundation outside of the cell with riprap or by driving the piling to a sufficient depth beneath the anticipated scour. Deflectors designed to streamline flow are effective in minimizing scour along the face of the cofferdam. These deflectors consist of a curved sheet pile wall, with appropriate bracing, extending into the river from the outer upstream and downstream corners of the cofferdam. Figure 2-1 shows a schematic deflector layout. As noted previously, hydraulic model studies are useful in predicting the potential for scour and in developing the most efficient deflector geometry. For a detailed discussion of deflectors, refer to EM 1110-2-1611.

b. Berms. A soil berm may be constructed inside the cells to provide additional sliding and overturning resistance. The berm will also serve to lengthen the seepage path and decrease the upward seepage gradients on the interior of the cells. However, a berm will require a larger cofferdam enclosure and an increase in the overall length of the cofferdam, and will increase construction and maintenance costs. Also, an inside berm inhibits inspection of the inside piling for driving damage and makes cell drainage maintenance more difficult. It is generally advisable, therefore, to increase the diameter of the cells instead of constructing a berm to achieve stability since the amount of piling per lineal foot of cofferdam is, essentially, independent of the diameter of the cells. Any increase in the diameter of the cells must be within the limitations of the maximum allowable interlock stress, as discussed in Chapter 4. In order for a berm to function as designed, the berm must be constantly maintained and protected against erosion and the degree of saturation must be consistent with design assumptions. Berm material properties and design procedures are discussed in Chapters 3 and 4.

c. Flooding Facilities. Flooding of a cofferdam by overtopping can cause serious damage to the cofferdam, perhaps even failure. An overflow can wash fill material from the cells and erode berm material. Before overtopping occurs, the cofferdam should therefore be filled with water in a controlled manner by providing floodgates or sluiceways. The floodgates or sluiceways can also be used to facilitate removal of the cofferdam by flooding. Floodgates are constructed in one or more of the connecting arcs by cutting the piling at the appropriate elevation and capping the arc with concrete to provide a nonerodible surface. Control is maintained by installing timber needle beams that can be removed when flooding is desired. Figure 2-2 shows a typical floodgate arrangement. Sluiceways consist of a steel pipe placed through a hole cut in the piling of a connecting arc. Flow is controlled by means of

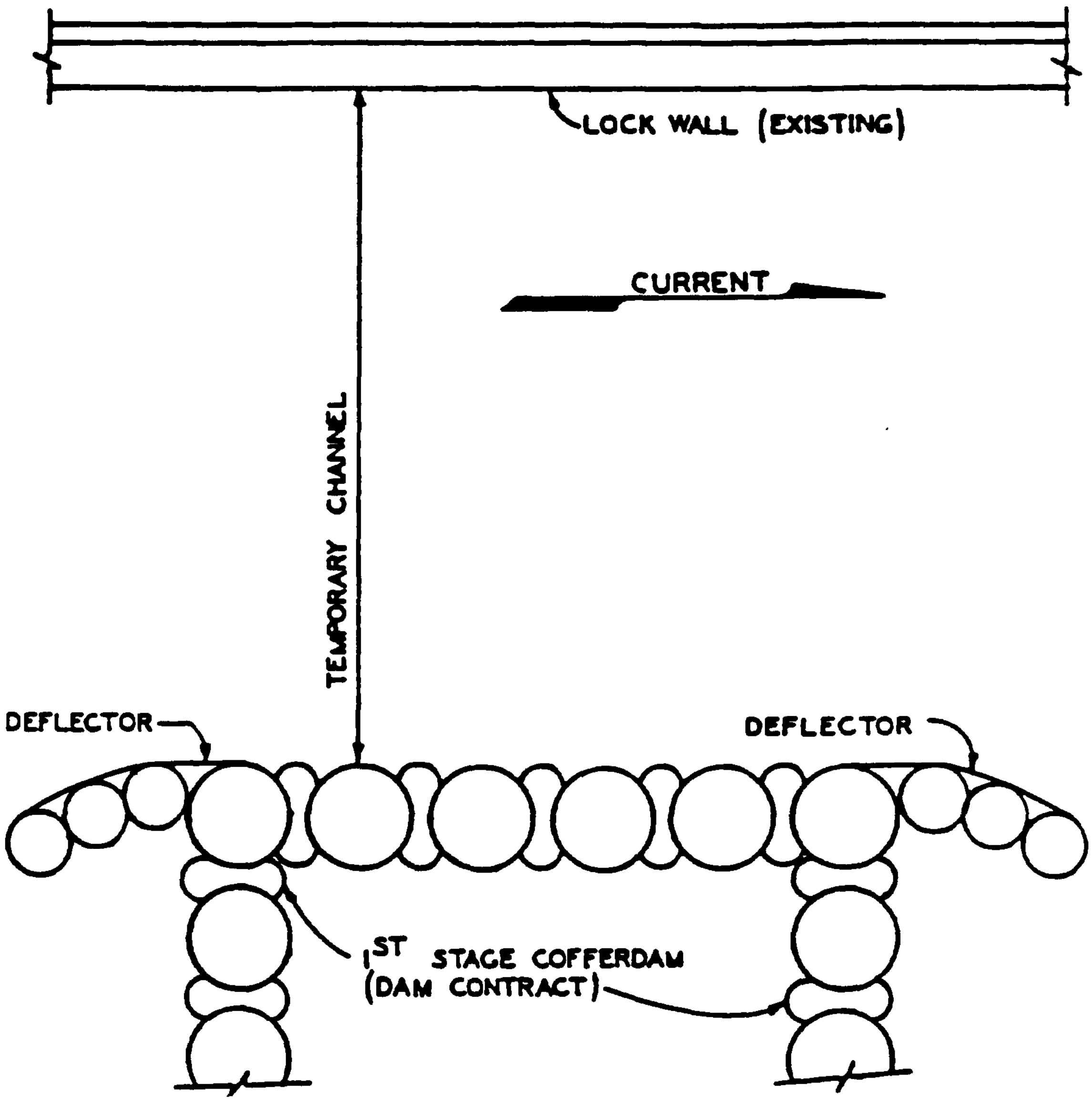

Figure 2-1. Schematic deflector layout

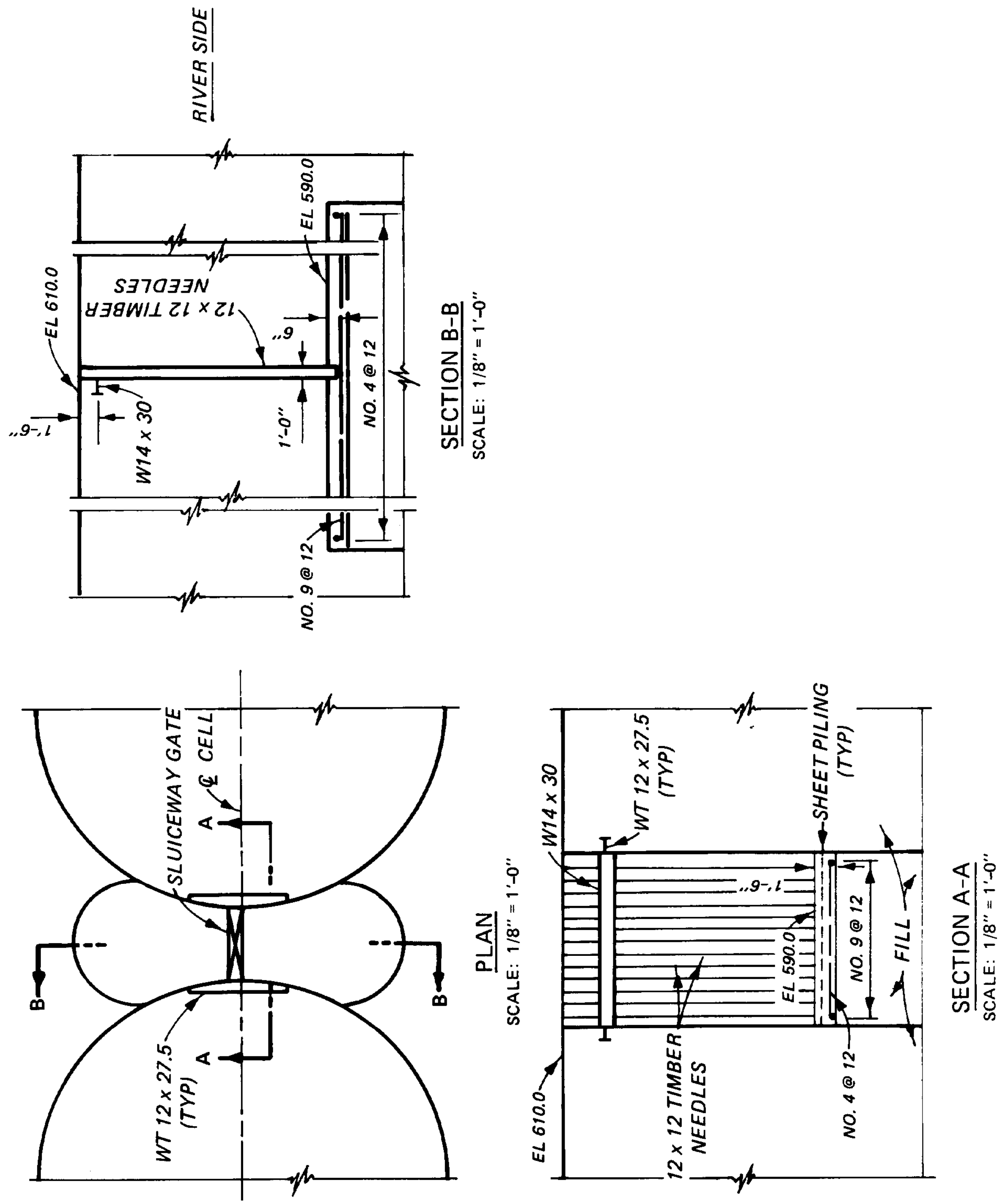

Figure 2-2. Typical floodgate arrangement

a slidegate or valve operated from the top of the cell. The size, number, and invert elevations of the flooding facilities are determined by comparing the volume to be filled with the probable rate of rise of the river. These elements must be sized so that it is possible to flood the cofferdam before it is overtopped. For either system, the adjacent berm must be protected against the flows by means of a concrete flume, a splashpad, or heavy stone.

d. Tie-ins. Cofferdams often must be connected to land and to completed portions of the structure.

(1) Tie-in to Land. Where the cofferdam joins a steep sloping shoreline, the first cell is usually located at a point where the top of the cell intersects the sloping bank. A single wall of steel sheet piling connected to the cell and extending landward to form a cutoff wall is often required to increase the seepage path and reduce the velocity of the water. The length of the cutoff wall will depend upon the permeability of the overburden. The wall should be driven to rock or to a depth in overburden as required by the permeability of the overburden. The depths of overburden into which the cells and cutoff wall are driven should be limited to 30 feet in order to prevent driving the piling out of interlock. Otherwise, it will be necessary to excavate a portion of the overburden prior to driving the piling. Where the cofferdam abuts a wide floodplain which is lower than the top of the cofferdam cells, protection from floodwaters along the land side can be obtained by constructing an earth dike with a steel sheet pile cutoff wall. The dike may join the upstream and downstream arms of the cofferdam or extend from the end of the cofferdam into the bank, depending upon the type of overburden, location of rock, and extent of the floodplain.

(2) Tie-in to Existing Structures. Tie-ins to a vertical face of a structure can be accomplished by embedding a section of sheet piling in the structure to which a tee pile in the cell can be connected. Another method of tie-in to a vertical face consists of wedging a shaped-to-fit timber beam between the cell and the vertical face. As the cofferdam enclosure is dewatered, the hydrostatic pressure outside the cofferdam seats the beam, thus creating a seal. Tie-ins to a sloping face are somewhat more complicated, and it is necessary to develop details to fit each individual configuration. The most common schemes consist of timber bulkheads or timber cribs tailored to fit the sloping face. See Figure 2-3 for typical tie-in details.

e. Cell Layout and Geometry. The cofferdam layout, generally, should utilize only one cell size which satisfies all design requirements. In some areas it might be possible to meet all stability requirements with smaller cells; however, the additional costs resulting from the construction and use of more than one size template will usually exceed the additional cost of an increase in the cell diameter. The geometry of the various cell types was discussed in Chapter 1. For individual cell and connecting arc geometry, the arrangements and criteria contained in the Steel Sheet Piling Handbook published by the U. S. Steel Corporation (items 87 and 88) are recommended. These suggested arrangements should, however, be modified to require an odd number of piles between the connecting wyes or tees as shown in Figure 2-4.

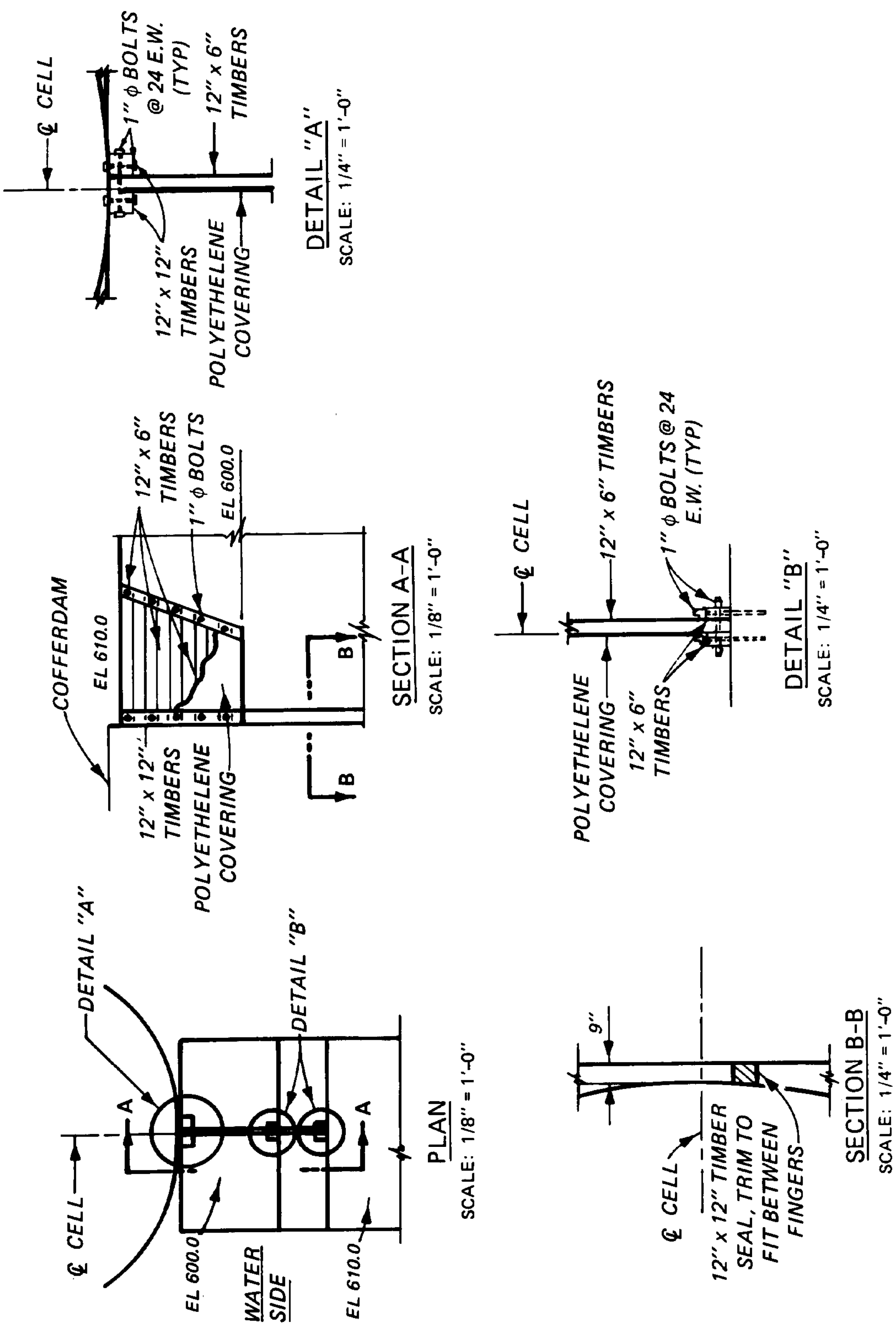

Figure 2-3. Typical tie-in details

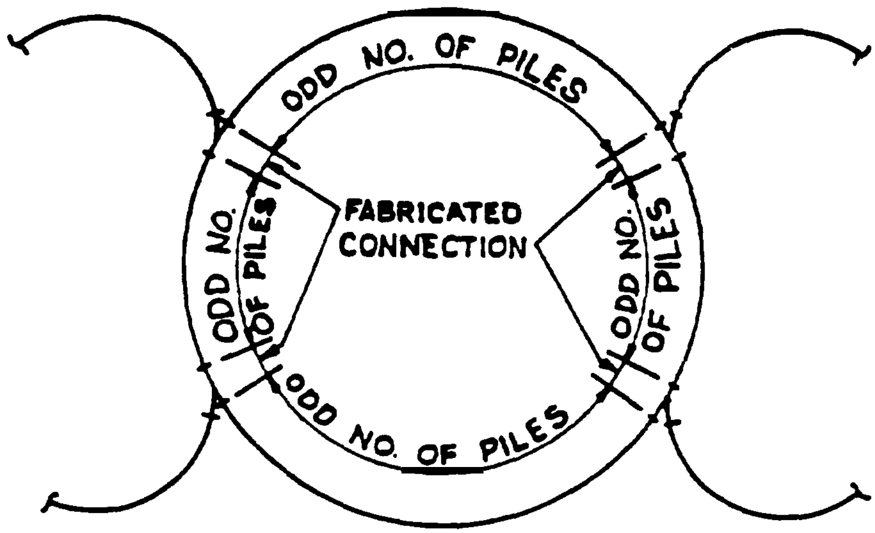

Figure 2-4. Arrangements of connecting wyes and tees

This will allow the use of only one type of fabricated wye or tee rather than two types if an even number of piles are used between connections. Although two additional piles might be required for each cell, this cost would be offset by the ease of checking shop drawings and simplifying construction, i.e., the tees or wyes could not be placed and driven in the wrong location. In developing details for other configurations, special attention should be given to the location of tees or wyes and the number of piles between connections.

f. Protection and Safety Features. Other features which must be considered in the planning and layout of a cofferdam include: a rock or concrete cap on the cell to protect the cell fill from erosion and to provide a suitable surface for construction equipment; personnel safety facilities including sufficient stairways and an alarm system; and navigation warnings, including painting of cells, reflective panels, and navigation lights.